ORIGINAL ARTICLE

Indwelling Urinary Catheter Use in the Postoperative Period

Analysis of the National Surgical Infection Prevention Project Data

Heidi L. Wald, MD, MSPH; Allen Ma, PhD; Dale W. Bratzler, DO, MPH; Andrew M. Kramer, MD

Objectives: To describe the frequency and duration of perioperative catheter use and to determine the relationship between catheter use and postoperative outcomes.

Design: Retrospective cohort study.

Setting: Two thousand nine hundred sixty-five acute care US hospitals.

Patients: Medicare inpatients (N = 35 904) undergoing major surgery (coronary artery bypass and other open-chest cardiac operations; vascular surgery; general abdominal colorectal surgery; or hip or knee total joint arthroplasty) in 2001.

Main Outcome Measure: Postoperative urinary tract infection.

Results: Eighty-six percent of patients undergoing major operations had perioperative indwelling urinary catheters. Of these, 50% had catheters for longer than 2 days postoperatively. These patients were twice as likely to develop urinary tract infections than patients with catheterization of 2 days or less. In multivariate analyses, a postoperative catheterization longer than 2 days was associated with an increased likelihood of in-hospital urinary tract infection (hazard ratio, 1.21; 95% confidence interval [CI], 1.04-1.41) and 30-day mortality (parameter estimate, 0.54; 95% CI, 0.37-0.72) as well as a decreased likelihood of discharge to home (parameter estimate, −0.57; 95% CI, −0.64 to −1.51).

Conclusions: Indwelling urinary catheters are routinely in place longer than 2 days postoperatively and may result in excess nosocomial infections. The association with adverse outcomes makes postoperative catheter duration a reasonable target of infection control and surgical quality-improvement initiatives.

Arch Surg. 2008;143(6):551-557

PERIOPERATIVE INDWELLING urinary catheter use has become ubiquitous. In the late 1990s, patients were exposed to urinary catheters on 85% of their days in the intensive care unit.[1] High rates of perioperative catheter use are intended to reduce postoperative bladder dysfunction related to anesthesia, analgesia, and immobility.[2-4] Any benefit of urinary catheters for patients postoperatively is offset, however, by the substantial risk of a urinary tract infection (UTI), accrued in direct relationship with the duration of catheterization, estimated to be 5% to 10% per catheter-day beyond the first 48 hours of catheterization.[5,6] The consequences of catheter-associated UTIs are significant and include prolonged hospital stay, bacteremia, prosthetic joint infection, and death,[4,7] thus providing a strong rationale for limiting the duration of urinary catheterization postoperatively to 48 hours unless ongoing bladder dysfunction prohibits removal.

CME available online at www.jamaarchivescme.com and questions on page 530

Only a limited number of prospective studies address optimal bladder management for surgical patients—most are small, single-institution studies on orthopedic surgical services.[3,4,8-10] Therefore, in the absence of guidance from the medical literature, most authors suggest limiting postoperative urinary catheterization to no longer than 48 hours. Despite these recommendations, a clear standard of care for postoperative bladder management has not emerged.

The National Surgical Infection Prevention Project, a collaboration between the Centers for Medicare & Medicaid Services and the Centers for Disease Control and Prevention, promoted practices that

Author Affiliations: Division of Health Care Policy and Research, University of Colorado Denver School of Medicine, Denver (Drs Wald and Kramer); and Oklahoma Foundation for Medical Quality, Inc, Oklahoma City (Drs Ma and Bratzler).

reduce the risk of surgical site infections.[11] From their baseline data collection, we obtained information about processes of care, including urinary catheter use, and outcomes. Using these data pertaining to Medicare patients undergoing selected major operations, we could (1) describe the frequency and duration of perioperative urinary catheter use and (2) test the hypothesis that urinary catheter use longer than 2 days postoperatively is negatively associated with postoperative outcomes when compared with urinary catheter use 2 days or less.

METHODS

DESIGN

The National Surgical Infection Prevention Project was a retrospective cohort study that evaluated 3 performance measures of the use of antimicrobial prophylaxis to prevent surgical site infections.[11] Access to these data is provided to the Medicare program by statute; therefore, informed consent of the participants was not required. This study was approved and considered exempt from periodic continuing review by the Colorado Multiple Institutional Review Board.

PARTICIPANTS

Two thousand nine hundred sixty-five acute care US hospitals served as the study setting. The study participants included a systematic random sample of 39 086 Medicare fee-for-service beneficiaries who underwent selected operations between January 1 and November 30, 2001. Eligible operations included Medicare Part A claims with a principal or secondary *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*), procedure code for coronary artery bypass surgery and other open-chest cardiac operations (excluding transplantation); vascular surgery (including aneurysm repair, thromboendarterectomy, and vein bypass operations); general abdominal colorectal surgery; or hip or knee total joint arthroplasty (excluding revision surgery). We excluded 2910 patients who underwent either abdominal or vaginal hysterectomies because of these organs' proximity to the urinary tract, 205 patients who did not undergo a procedure of interest, 61 patients for whom catheter presence could not be determined from their medical records, and 6 patients younger than 18 years, leaving an eligible pool of 35 904 participants.

SAMPLING

A systematic random sample of 788 cases from each state or territory was used to create the National Surgical Infection Prevention Project data set before exclusions. If fewer than 750 medical records were available from a state or territory based on the surgical procedures mentioned, all eligible discharges were reviewed.[11] As a result of this sampling strategy, the number of study participants per hospital ranged from 1 to 418. More than half of the hospitals (n = 1571) contributed 5 or fewer records to the data set.

DATA COLLECTION

Photocopied hospital records for the selected study participants were sent from hospitals to 1 of 2 clinical data-abstraction centers. Medical records were hand abstracted using computerized tools with explicit predefined criteria to record data elements. Reliability was determined on a subset of 559 records reviewed by a second abstractor. The κ statistics for the data fields coding the presence of a urinary catheter, removal of the urinary catheter, and postoperative UTI were 1.0, 0.74, and, 0.74 respectively, indicating excellent reliability.

MAIN OUTCOME MEASURES

The primary outcome measure was occurrence of a postoperative UTI during the index hospitalization. Urinary tract infection was abstracted from physician notes and orders indicating treatment for a UTI at any time following the first surgical procedure of interest. *Urosepsis* was a synonym for UTI. Secondary outcomes included discharge location (home vs other), abstracted from medical record discharge notes, and 30-day operative mortality obtained from the Medicare death file.

Primary Effect Variable

The primary effect variable was the duration of indwelling urinary catheterization during the first surgical procedure of interest. Catheter insertion was abstracted from the preoperative checklist, nursing notes, or the operating room or procedure reports or notes. Synonyms used by the abstractors for the term *urinary catheter* included *Foley catheter*, *coudee catheter*, *indwelling catheter*, *suprapubic catheter*, and *3-way catheter*. Exclusions used by the abstractors for the term *urinary catheter* included *catheterize prn for residual urine*, *ileal conduit*, *in and out cath*, *intermittent or spot caths*, *self-catheterization*, and *urinary diversion*. Removal of the catheter was documented in the physician's orders. Postoperative duration of catheterization was calculated as the catheter removal date minus the surgical date. We defined the total number of urinary catheter–days per 1000 hospital-days for each operation type as the sum of the number of days catheterized for each patient divided by the sum of the number of hospital-days for each patient multiplied by 1000. Higher numbers for this measure reflect either later removal of catheters or shorter hospital lengths of stay (LOSs).

For use in the outcome models, the duration of indwelling urinary catheterization was dichotomized at 2 days. This 2-day cutoff was chosen based on a literature review, which suggested that infectious complications from urinary catheters are unlikely to occur before 48 hours after insertion.[5,6]

Covariates

Patient-level independent risk factors are listed in **Table 1** and include age, sex, race, preadmission setting (nursing facility or other), American Society of Anesthesiologists score, comorbid conditions, and in-hospital complications. The American Society of Anesthesiologists score is a preoperative rating assigned to each patient, measuring the patient's general health status and coexisting conditions.[12] Scores range from I (healthy) to VI (moribund). Three in-hospital complications were included: postoperative sepsis, postoperative pneumonia, and any major noninfectious complication. The major noninfectious complications included shock, cardiac arrest, myocardial infarction, congestive heart failure, bleeding, pulmonary embolism, stroke, and major medication reaction. Each diagnosis was abstracted and recorded separately but was collapsed to 1 category for this analysis. All patient-level covariates were abstracted from medical records.

Comorbid conditions were obtained from *ICD-9-CM* codes from the Medicare Part A claim for the hospitalization of interest using the Elixhauser method, which only counts comorbid conditions not related to the admitting diagnosis-related group.[13] In addition to these diagnoses, comorbid conditions were chosen based on our findings in prior published stud-

Table 1. Patient Characteristics by Operation Type

Characteristic	Operation Type					*P* Value
	Orthopedic (n=11 770)	Cardiac (n=8790)	Vascular (n=3657)	GI (n=6730)	All (N=30 947)	
Age, mean (SD), y	76 (9)	72 (8)	73 (9)	75 (9)	74 (9)	< .001
Female sex, %	70.1	36.9	39.3	58.0	54.4	< .001
White race, %	90.9	89.5	85.8	87.0	89.0	< .001
Hospital length of stay, mean (SD), d	5.2 (3.5)	10.6 (11.7)	9.5 (10.5)	11.5 (9.7)	8.6 (9.2)	< .001
Admitted from nursing facility, %	6.1	0.3	3.0	4.5	3.7	< .001
ASA score, %						
I	1.5	0.1	0.1	1.0	0.8	< .001
II	38.7	0.6	7.3	29.5	22.2	
III	48.7	28.7	61.6	51.1	45.1	
IV	7.0	66.7	25.5	14.0	27.7	
V	0.1	0.9	1.8	0.8	0.7	
VI	0	0	0.1	0	0	
Indeterminable	3.9	2.9	3.6	3.7	3.5	
In-hospital complication, %						
Postoperative pneumonia	2.2	5.5	5.4	6.8	4.5	< .001
Postoperative sepsis	0.4	2.7	2.9	5.2	2.4	< .001
Any major noninfectious complication	6.8	23.1	20.5	19.6	15.8	< .001
Comorbid condition, %						
Anemia	12.8	6.8	7.7	16.7	11.4	< .001
Bleeding disorder	1.3	5.9	4.0	2.4	3.2	< .001
Cancer	0.7	0.1	0.3	21.1	4.9	< .001
Chronic pulmonary disease	13.9	20.2	28.2	17.4	18.1	< .001
Congestive heart failure	7.9	1.2	9.7	12.0	7.1	< .001
Delirium	1.3	1.2	1.1	1.4	1.3	.67
Dementia	7.9	0.6	1.8	3.2	4.1	< .001
Diabetes	14.1	27.7	25.8	14.1	19.4	< .001
Hypertension	53.8	55.8	56.2	40.1	51.7	< .001
Renal failure	1.2	3.7	5.0	2.0	2.5	< .001
Stroke	0.2	0.6	0.2	0.3	0.3	< .001
Diagnosis justifying urinary catheterization, %						
Urinary retention	1.7	1.5	1.8	2.5	1.8	< .001
Bladder outlet obstruction	0.3	0.6	0.3	0.5	0.4	.005
Paralysis	1.2	0.9	1.5	1.2	1.1	.04
Other neurogenic bladder	0.2	0.0	0.1	0.3	0.2	< .001
Multiple sclerosis	0.1	0.0	0.2	0.3	0.1	< .001
Prostate disease	2.3	2.6	2.2	2.4	2.4	.41
Any diagnosis justifying urinary catheter	5.5	5.4	5.8	6.7	5.8	.003

Abbreviations: ASA, American Society of Anesthesiologists; GI, gastrointestinal.

ies.[14,15] Of particular interest was the presence of comorbidities that might justify chronic indwelling catheterization (including urinary retention, bladder outlet obstruction, paresis, multiple sclerosis, and prostate conditions). These diagnoses were determined through clinical considerations and directed by published guidelines, which consider complicated urinary retention to be the major indication for chronic indwelling catheters.[16] The operation type was determined by the primary surgical procedure and included orthopedic, cardiac, vascular, and gastrointestinal operations.

STATISTICAL ANALYSIS

We performed analysis of variance or the χ^2 test for patient characteristics across operation types. We also compared catheter-use patterns across surgical types using these same procedures.

Survival analysis was the primary method for examining the main outcome measure—postoperative UTI—because patients differed in duration of follow-up, ie, hospital LOS. We determined the cumulative probability of a postoperative UTI diagnosis for each postoperative day using the Kaplan-Meier approach stratified by catheterization 2 days or shorter or longer than 2 days. Patients whose records did not have a catheter-removal order documented were censored at discharge. A Cox proportional hazards model was estimated to adjust for predictors of in-hospital postoperative UTI from among patient and surgery characteristics. We adjusted for the effect of clustering of observations in hospitals using the robust sandwich estimate of Lin and Wei.[17] To correct for covariates violating the proportionality assumption of the Cox model, interaction terms reflecting the time dependence of the covariates were included in the final model. The Cox model was assessed using the global goodness-of-fit statistic and residual plot analysis.

To verify that the Cox model adequately accounted for the effects of clustering in hospitals, the risk of any postoperative UTI was also predicted using a hierarchical random-effects model controlling for patient and surgery characteristics. Because the results from the Cox models and the hierarchical models were found to be similar, only the Cox proportional hazards model is reported.

To identify predictors of the dichotomous outcomes of discharge location (home vs other) and 30-day operative mortality, hierarchical random-effects models were used, control-

Table 2. Perioperative Urinary Catheter Duration by Operation Type

Measure	Operation Type					*P* Value
	Orthopedic (n=11 770)	Cardiac (n=8790)	Vascular (n=3657)	GI (n=6730)	All (N=30 947)	
Documented catheter-removal order, No. (%)	9738 (82.7)	7242 (82.4)	2971 (81.2)	5508 (81.8)	25 459 (82.3)	.15
Cases with catheter-removal orders						
Catheter duration, mean (SD), median, d	2.5 (3.6), 2	3.5 (5.2), 2	4.1 (5.6), 3	5.1 (5.0), 4	3.5 (4.8), 2	< .001
Catheter duration > 2 d, %	45.1	54.2	62.0	80.3	57.3	< .001
Catheter-days/1000 hospital-days	448	296	390	397	374	< .001
Catheter removal on day of discharge, %	7.4	1.6	5.0	4.9	5.1	< .001

Abbreviation: GI, gastrointestinal.

Table 3. Unadjusted Rates of Postoperative Outcomes by Operation Type

Outcome	No. (%)					*P* Value
	Orthopedic (n=11 770)	Cardiac (n=8790)	Vascular (n=3657)	GI (n=6730)	All (N=30 947)	
In-hospital UTI	3.4	3.3	3.4	4	3.5	
Discharge to home	26.7	74.1	68.4	68.6	54.2	< .001
30-Day postoperative mortality	2.6	5	6.3	8.6	5.1	< .001

Abbreviations: GI, gastrointestinal; UTI, urinary tract infection.

ling for patient and surgery characteristics and accounting for the clustering of observations in hospitals. The choice of independent variables was driven by clinical hypotheses and informed by prior work. All covariates of interest were tested in general linear regression and logistic regression models as appropriate before inclusion in the Cox and hierarchical models. All analyses were completed using SAS, version 9.13 (SAS Institute Inc, Cary, North Carolina), and all the test results were defined as significant at $P < .05$.

RESULTS

PATIENT CHARACTERISTICS

Eighty-six percent of surgical patients meeting study criteria had perioperative urinary catheters. Cases without catheters (n=4957) were overwhelmingly orthopedic, with a diagnosis of renal failure (80%). Patients without catheters were excluded from further analysis, because they were not relevant to our main hypothesis. In addition, they comprise a clinically distinct patient population in whom the reasons for receiving or not receiving a perioperative urinary catheter are unknown.

Of the 30 947 remaining surgical records, 38% were for orthopedic procedures, 28% were for cardiac procedures, 12% were for vascular procedures, and 22% were for gastrointestinal procedures. Study participants were elderly (mean [SD] age, 74 [9] years), white (89%), and more likely to be female (54%). Table 1 displays comparisons by operation type, revealing distinct surgical populations regarding demographics, American Society of Anesthesiologists score, comorbid conditions, and complications. Patients who underwent orthopedic operations had fewer in-hospital complications; less chronic pulmonary disease, diabetes, and renal failure; and shorter hospital LOS compared with patients who underwent cardiac, vascular, or gastrointestinal operations.

PATTERNS OF POSTOPERATIVE FOLEY CATHETERIZATION

For patients with perioperative urinary catheters, **Table 2** presents catheter-use patterns by operation type. Among these patients, 82% had a urinary catheter–removal order documented before discharge, a rate that was consistent across surgical services. Patients who underwent orthopedic operations had the shortest mean catheterization (2.5 days), while patients undergoing gastrointestinal operations had the longest mean catheterization (5.1 days). Orthopedic operations also had the most urinary catheter–days per 1000 hospital-days of any surgical service owing to their short hospital LOS (n=488).

POSTOPERATIVE OUTCOMES

Rates of postoperative outcomes are presented in **Table 3**. We found that unadjusted rates of UTIs were similar across all surgical services, while the rates of discharge to home and 30-day mortality differed. Orthopedic cases had lower rates of discharge to home, most likely related to their routine discharge to rehabilitation settings, and lower mortality rates. The cumulative probability of having a diagnosis of and being treated for a UTI was twice as high for patients with a catheterization of longer than 2 days than for patients with a catheterization of 2 days or shorter (9.4% vs 4.5%; log-rank test, $P=.004$), as shown in the Kaplan-Meier curves (**Figure**).

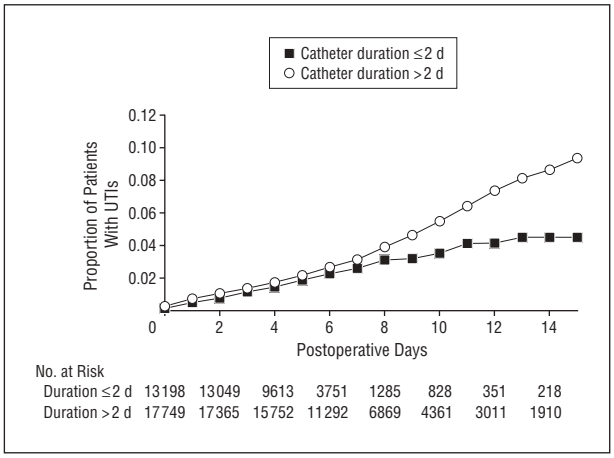

Figure. Cumulative probability of urinary tract infection (UTI) by postoperative catheterization. Log-rank test for difference between curves, $P=.004$. The difference first becomes significant at day 9.

Table 4 contains the results of the Cox proportional hazards model assessing the relationship between catheterization longer than 2 days postoperatively and time to UTI, after adjusting for patient and surgery characteristics. The strongest predictors of shorter time to UTI were postoperative sepsis, any diagnosis justifying chronic urinary catheter, nursing home residence, dementia, and male sex. Catheterization longer than 2 days remained a significant predictor of time to UTI (hazard ratio, 1.21; 95% confidence interval, 1.04-1.41) in our model.

Table 5 contains the hierarchical model relating a catheterization of longer than 2 days postoperatively with discharge to home, adjusting for patient and operation characteristics. Operation type (cardiac, vascular, and gastrointestinal) and age younger than 75 years were the strongest predictors of 30-day discharge to one's home, and nursing home residence was the strongest predictor of discharge to a location other than one's home. Catheter duration of longer than 2 days was significantly associated with discharge to a location other than one's home (parameter estimate, –0.57; 95% confidence interval, –0.64 to –0.51).

The strongest predictors of 30-day operative mortality (**Table 6**) were noninfectious complications, renal failure, nursing home residence, and stroke. Sensitivity analysis of 30-day operative mortality was performed by removing all early deaths (within 3 days of surgery). The relationship between catheter duration and 30-day postoperative mortality remained significant (parameter estimate, 0.54; 95% confidence interval, 0.37-0.72).

Table 4. Cox Proportional Hazards Model Identifying Patient and Surgery Characteristics Associated With Shorter Time to Postoperative Urinary Tract Infection (N=30 947)[a]

Variable	Hazard Ratio (95% Confidence Interval)	*P* Value
Urinary catheter > 2 days	1.21 (1.04-1.41)	.02
Age	1.03 (1.01-1.04)	< .001
Female sex	0.59 (0.52-0.67)	< .001
White race	1.01 (0.82-1.24)	.95
Nursing home residence	1.34 (1.04-1.71)	.02
Anemia	1.10 (0.92-1.31)	.31
Bleeding disorder	0.90 (0.69-1.19)	.46
Cancer	0.90 (0.68-1.20)	.48
Chronic pulmonary disease	0.79 (0.68-0.93)	.004
Congestive heart failure	1.02 (0.86-1.21)	.81
Delirium	0.98 (0.62-1.55)	.93
Dementia	1.31 (1.01-1.69)	.04
Diabetes	1.01 (0.85-1.20)	.94
Hypertension	0.87 (0.76-0.99)	.03
Renal failure	1.03 (0.74-1.44)	.86
Stroke	0.60 (0.25-1.44)	.26
Diagnosis justifying urinary catheterization[b]	1.43 (1.12-1.83)	.004
American Society of Anesthesiologists score	1.26 (1.06-1.50)	.007
Postoperative pneumonia	1.21 (1.01-1.46)	.04
Postoperative sepsis	3.78 (2.34-6.12)	< .001
Postoperative noninfectious complications	1.27 (1.07-1.50)	.006
Operation type		
Orthopedic	1 [Reference]	
Cardiac	0.23 (0.16-0.33)	< .001
Gastrointestinal	0.22 (0.15-0.32)	< .001
Vascular	0.26 (0.16-0.41)	< .001
Time-dependent variables		
Age × time[a]	0.99 (0.98-1.00)	.02
Cardiac surgery × time[a]	1.78 (1.44-2.19)	< .001
Gastrointestinal surgery × time[a]	1.67 (1.34-2.07)	< .001
Vascular surgery × time[a]	1.69 (1.35-2.13)	< .001
American Society of Anesthesiologists score × time[a]	0.90 (0.83-0.97)	.008
Postoperative sepsis × time[a]	0.66 (0.54-0.80)	< .001

[a] Goodness of fit: log likelihood ratio test = 393.5862_{30}, $P<.001$.
[b] Includes urinary retention, bladder outlet obstruction, paresis, multiple sclerosis, and prostate conditions.

COMMENT

Indwelling urinary catheters are routine in perioperative care. As with many medical interventions, the benefits of urinary catheters must be considered in the context of their associated adverse effects, namely, catheter-associated UTIs. The results of this national study show that perioperative urinary catheterization is nearly universal for Medicare beneficiaries undergoing major operations and suggest that patients with postoperative catheterization longer than 2 days are more likely to experience adverse outcomes.

The association we found between postoperative duration of a urinary catheter and a UTI is consistent with prior literature documenting a relationship between duration of catheterization and rates of bacteriuria and UTI and suggests a mechanism through which long catheterization could result in decreased discharges to home and increased mortality[5,6] Among patients with UTIs, an estimated 3.6% will develop bacteremia—a condition that adds significantly to hospital LOS[18] and is a risk factor for death among elderly patients.[19]

We found that the increased rate of UTIs in patients with catheterizations longer than 2 days is apparent only after postoperative day 6. The observed lag time may be due to the conservative case definition, ie, the UTI must have been documented as having been treated. The lag time suggests that a significant number of UTIs may have been missed among patients dis-

Table 5. Random-Effects Hierarchical Model Identifying Patient and Surgery Characteristics Associated With Discharge to Home (N=30 947)[a]

Variable	Parameter Estimate (95% Confidence Interval)	*P* Value
Urinary catheter > 2 d	– 0.57 (– 0.64 to – 0.51)	< .001
Age, y		
< 65	1.70 (1.56 to 1.84)	< .001
65-74	1.59 (1.48 to 1.71)	< .001
75-84	0.83 (0.72 to 0.94)	< .001
≥ 85	1 [Reference]	
Female sex	0.60 (0.55 to 0.66)	< .001
White race	0.10 (0.01 to 0.20)	.03
Nursing home residence	– 3.47 (– 3.92 to – 3.03)	< .001
Anemia	– 0.07 (– 0.16 to 0.03)	.16
Bleeding disorder	– 0.36 (– 0.53 to – 0.20)	< .001
Cancer	– 0.12 (– 0.26 to 0.02)	.1
Chronic pulmonary disease	– 0.15 (– 0.22 to – 0.08)	< .001
Congestive heart failure	– 0.38 (– 0.51 to – 0.25)	< .001
Delirium	– 0.26 (– 0.51 to – 0.01)	.045
Dementia	– 0.94 (– 1.17 to – 0.72)	< .001
Diabetes	– 0.21 (– 0.29 to – 0.14)	< .001
Hypertension	0.18 (0.12 to 0.25)	< .001
Renal failure	– 0.84 (– 1.03 to – 0.65)	< .001
Stroke	– 1.57 (– 2.11 to – 1.04)	< .001
Diagnosis justifying chronic urinary catheterization[b]	– 0.27 (– 0.39 to – 0.14)	< .001
American Society of Anesthesiologists score	– 0.32 (– 0.37 to – 0.28)	< .001
Postoperative pneumonia	– 1.49 (– 1.70 to – 1.28)	< .001
Postoperative sepsis	– 0.72 (– 0.87 to – 0.57)	< .001
Postoperative noninfectious complications	– 1.09 (– 1.18 to – 1.00)	< .001
Operation type		
Orthopedic	1 [Reference]	
Cardiac	2.63 (2.51 to 2.76)	< .001
Gastrointestinal	2.77 (2.65 to 2.88)	< .001
Vascular	2.41 (2.29 to 2.53)	< .001

[a] Goodness of fit: deviance/*df*=0.9556. A *P* Value is not computed for the deviance; however, a deviance that is approximately equal to its degrees of freedom is a possible indication of a good model fit.
[b] Includes urinary retention, bladder outlet obstruction, paresis, multiple sclerosis, and prostate conditions.

Table 6. Random-Effects Hierarchical Model Identifying Patient and Surgery Characteristics Associated With 30-Day Operative Mortality (N=30 947)[a]

Variable	Parameter Estimate (95% Confidence Interval)	*P* Value
Urinary catheter > 2 d	0.54 (0.37 to 0.72)	< .001
Age, y		
< 65	– 1.02 (– 1.30 to – 0.75)	< .001
65-74	– 0.99 (– 1.17 to – 0.81)	< .001
75-84	– 0.68 (– 0.85 to – 0.52)	< .001
≥ 85	1 [Reference]	
Female sex	0.03 (– 0.10 to 0.15)	.68
White race	0.13 (– 0.07 to 0.32)	.20
Nursing home residence	0.83 (0.59 to 1.07)	< .001
Anemia	– 0.36 (– 0.56 to – 0.17)	< .001
Bleeding disorder	0.61 (0.40 to 0.83)	< .001
Cancer	0.67 (0.44 to 0.90)	< .001
Chronic pulmonary disease	0.15 (0.01 to 0.28)	.04
Congestive heart failure	0.03 (– 0.14 to 0.21)	.72
Delirium	– 0.70 (– 1.32 to – 0.09)	.03
Dementia	0.77 (0.52 to 1.01)	< .001
Diabetes	– 0.10 (– 0.26 to 0.06)	.23
Hypertension	– 0.52 (– 0.65 to – 0.39)	< .001
Renal failure	0.94 (0.68 to 1.19)	< .001
Stroke	0.82 (0.24 to 1.40)	.005
Diagnosis justifying chronic urinary catheterization[b]	– 0.34 (– 0.61 to – 0.08)	.01
American Society of Anesthesiology score	0.56 (0.46 to 0.67)	< .001
Postoperative pneumonia	– 0.11 (– 0.30 to 0.08)	.24
Postoperative sepsis	0.56 (0.35 to 0.77)	< .001
Postoperative noninfectious complications	2.08 (1.95 to 2.22)	< .001
Operation type		
Orthopedic	1 [Reference]	
Cardiac	– 0.15 (– 0.36 to 0.06)	.17
Gastrointestinal	0.52 (0.33 to 0.71)	< .001
Vascular	0.26 (0.05 to 0.48)	.02

[a] Goodness of fit: deviance/*df*=0.2920. A *P* value is not computed for the deviance; however, a deviance that is approximately equal to its degrees of freedom is a possible indication of a good model fit.
[b] Includes urinary retention, bladder outlet obstruction, paresis, multiple sclerosis, and prostate conditions.

charged early only to present in post–acute care. It is particularly relevant to orthopedic surgery, which has a shorter mean LOS (5.0 days) than other surgical procedures and is also associated with shorter time to UTI. These observations raise the concern that the postoperative UTI rate for orthopedic surgery patients is underestimated in our data.

In addition to its association with UTI, we found that postoperative urinary catheterization longer than 2 days was associated with increased mortality and decreased discharge to one's home. Even in the face of a plausible mechanism for these associations, urinary catheterization longer than 2 days need not directly cause these outcomes, but may alternatively or additionally be a marker of suboptimal postoperative care resulting in poor outcomes. Our mortality and discharge-location findings are also suggested by previous work in patients discharged to subacute rehabilitation postoperatively[14,20] and deserve further rigorous study.

Our results must be evaluated in the context of the study's limitations. In particular, most of our data were hand abstracted from medical records without direct observation of the presence or removal of catheters or laboratory results to diagnose UTIs. Rather, proxies in the medical record, such as a physician's order for catheter removal or documentation of treatment for a UTI, were used.

This methodological concern is of particular importance regarding the main effect variable, the postoperative duration of urinary catheters, which is dependent on the medical record documentation of catheter removal. Because catheter removal is underreported in medical records,[21,22] our data set cannot distinguish between patients whose catheters were not removed before discharge and patients whose catheters were removed in the absence of documentation. The unavoidable inclusion of these false-negative cases biases our results toward the null hypothesis, that there is no association of postoperative catheter duration and rates of postoperative outcomes.

Despite the study's limitations, our results contribute to ongoing efforts to understand and improve surgical outcomes for Medicare beneficiaries.[23] Reducing the duration of postoperative urinary catheterization might directly result in fewer postoperative UTIs, decreased hospital costs, and, in the case of bacteremic UTIs, decreased hospital LOSs and rehospitalizations.[7,14] Indirect effects might include a reduction in postoperative antibiotic use,[24] improved mobility,[25] and fewer falls.

While it has previously been recognized that urinary catheters—the cause of most nosocomial UTIs—are a patient safety concern,[1] the degree to which postoperative duration of urinary catheters can be reduced has not previously been studied. Measurement and feedback is one approach to quality improvement that has been used to improve performance of process-oriented quality measures in hospitals.[26] Measurement of urinary catheter duration might be achieved by extending existing infection-control surveillance efforts.[27] On receiving feedback, a hospital could design tailored interventions to reduce duration of postoperative urinary catheters, including education of clinicians or patients, reminders and feedback to clinicians,[28] or computerized automatic stop-orders.[22]

In conclusion, this work highlights postoperative duration of urinary catheterization as a potential indicator of quality of postoperative care applicable across surgical procedures. In contrast with surgery-specific outcomes (eg, mortality following coronary artery bypass grafting) or disease-specific processes of care (eg, rate of knee replacements), this work brings focus to a process of care to which most patients undergoing major operations are subject.

Accepted for Publication: January 23 2007.
Correspondence: Heidi L. Wald, MD, MSPH, Division of Health Care Policy and Research, University of Colorado Denver School of Medicine, 13611 E Colfax Ave, Ste 100, Aurora, CO 80011 (heidi.wald@uchsc.edu).
Author Contributions: The authors assume full responsibility for the accuracy and completeness of the ideas presented. *Study concept and design:* Wald, Bratzler, and Kramer. *Acquisition of data:* Ma. *Analysis and interpretation of data:* Wald and Ma. *Drafting of the manuscript:* Wald. *Critical revision of the manuscript for important intellectual content:* Wald, Ma, Bratzler, and Kramer. *Statistical analysis:* Wald, Ma, and Kramer. *Obtained funding:* Wald. *Study supervision:* Bratzler and Kramer.
Financial Disclosure: None reported.
Funding/Support: This study was supported in part by the Hartford/Jahnigen Center of Excellence in Aging and a National Research Service Award Primary Care Research Fellowship (Dr Wald).
Disclaimer: The analyses on which this publication is based were performed in part under the Centers for Medicare & Medicaid Services (contract No. 500-02-OK-03), an agency of the US Department of Health and Human Services. The content of this publication does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the US government.

REFERENCES

1. Centers for Disease Control and Prevention (CDC). Monitoring hospital-acquired infections to promote patient safety: United States, 1990-1999 [erratum published in *MMWR Morb Mortal Wkly Rep*. 2000;49(9):189-190]. *MMWR Morb Mortal Wkly Rep*. 2000;49(8):149-153.
2. Wells DL, Saltmarche A. Voiding dysfunction in geriatric patients with hip fracture: prevalence rate and tentative nursing interventions. *Orthop Nurs*. 1986; 5(6):25-28.
3. Skelly JM, Guyatt GH, Kalbfleisch R, Singer J, Winter L. Management of urinary retention after surgical repair of hip fracture. *CMAJ*. 1992;146(7):1185-1188.
4. Michelson JD, Lotke PA, Steinberg ME. Urinary bladder management after total joint-replacement surgery. *N Engl J Med*. 1988;319(6):321-326.
5. Schaeffer AJ. Catheter-associated bacteriuria. *Urol Clin North Am*. 1986;13(4):735.
6. Stamm WE. Guidelines for prevention of catheter-associated urinary tract infections. *Ann Intern Med*. 1975;82(3):386.
7. Saint S. Clinical and economic consequences of nosocomial catheter-related bacteriuria. *Am J Infect Control*. 2000;28(1):68-75.
8. Knight RM, Pellegrini JV. Bladder management after total joint arthroplasty. *J Arthroplasty*. 1996;11(8):882-888.
9. Johansson I, Athlin E, Frykholm L, Bolinder H, Larsson G. Intermittent versus indwelling catheters for older patients with hip fractures. *J Clin Nurs*. 2002; 11(5):651-656.
10. Iorio R, Whang W, Healy W, Patch DA, Najibi S, Appleby D. The utility of bladder catheterization in total hip arthroplasty. *Clin Orthop Relat Res*. 2005;432(432): 148-152.
11. Bratzler DW, Houck PM, Richards C, et al. Use of antimicrobial prophylaxis for major surgery: baseline results from the national surgical infection prevention project. *Arch Surg*. 2005;140(2):174-182.
12. American Society of Anesthesiologists. New classification of physical status [commentary]. *Anesthesiology*. 1963;24:111.
13. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8-27.
14. Wald H, Epstein A, Kramer A. Extended use of indwelling urinary catheters in postoperative hip fracture patients. *Med Care*. 2005;43(10):1009-1017.
15. Levy CR, Fish R, Kramer AM. Site of death in the hospital versus nursing home among Medicare skilled nursing facility residents admitted under Medicare's Part A Benefit. *J Am Geriatr Soc*. 2004;52(8):1247-1254.
16. American Medical Directors Association. *Clinical Practice Guideline: Urinary Incontinence*. Columbia, MD: American Medical Directors Association; 1996.
17. Lin DYWL, Wei LJ. The robust inference for the Cox proportional hazards model. *J Am Stat Assoc*. 1989;84(408):1074-1078.
18. Rose R, Hunting KJ, Townsend TR, et al. Morbidity/mortality and economics of hospital-acquired blood stream infections: a controlled study. *South Med J*. 1977; 70(11):1267-1269.
19. Emori TG, Banerjee SN, Culver DH, et al. Nosocomial infections in elderly persons in the United States, 1986-1990: National Nosocomial Infections Surveillance System. *Am J Med*. 1991;91(3B):289S-293S.
20. Wald HL, Epstein AM, Radcliff TA, Kramer AM. Extended use of urinary catheters in older surgical patients: a patient safety problem? *Infect Control Hosp Epidemiol*. 2008;29(2):116-124.
21. Saint S, Wiese J, Amory J, et al. Are physicians aware of which of their patients have indwelling urinary catheters? *Am J Med*. 2000;109(6):476-480.
22. Cornia PB, Amory JK, Fraser S, Saint S, Lipsky BA. Computer-based order entry decreases duration of indwelling urinary catheterization in hospitalized patients. *Am J Med*. 2003;114(5):404-407.
23. MedQIC. SCIP Project Information. http://www.medqic.org/dcs/ContentServer?cid=1122904930422&pagename=Medqic%2FContent%2FParentShellTemplate&parentName=Topic&c=MQParents. Accessed October 27, 2006.
24. Tambyah PA, Knasinski V, Maki DG. The direct costs of nosocomial catheter-associated urinary tract infection in the era of managed care. *Infect Control Hosp Epidemiol*. 2002;23(1):27-31.
25. Saint S, Lipsky B, Goold S. Urinary catheters: a one-point restraint? *Ann Intern Med*. 2002;137(2):125-127.
26. Marciniak TA, Ellerbeck EF, Radford MJ, et al. Improving the quality of care for Medicare patients with acute myocardial infarction. *JAMA*. 1998;279(17):1351-1357.
27. National Nosocomial Infections Surveillance System. National Nosocomial Infections Surveillance (NNIS) System Report: data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control*. 2004;32(8): 470-485.
28. Huang WC, Wann S, Lin S, et al. Catheter-associated urinary tract infections in intensive care units can be reduced by prompting physicians to remove unnecessary catheters. *Infect Control Hosp Epidemiol*. 2004;25(11):974-978.